SPECIFICATION

DEVICE FOR REMOVING LEAD SULFATE DEPOSITED ON SURFACES OF ELECTRODES OF A LEAD-ACID BATTERY

5 TECHNICAL FIELD

[0001]

The present invention relates to a device for removing lead sulfate deposited on electrodes of a lead-acid battery.

10 BACKGROUND ART

[0002]

With respect to a lead-acid battery, it has been known that, due to conditions during discharge and self-discharge, changes in ambient temperature when the battery

15 is left unused, vibration, etc., lead sulfate ($PbSO_4$) deposits build up and cover surfaces of electrode plates, which leads to an increase in internal resistance to such a degree that the lead-acid battery is no longer operable.

[0003]

20 In order to prevent the buildup of lead sulfate ($PbSO_4$) deposits, discharge conditions, temperature, vibration, etc. must be closely monitored. However, practically, in use of a lead-acid battery, it is nearly impossible to constantly monitor these conditions. Hence,

25 there has been a need for a new method for removing lead sulfate ($PbSO_4$) deposits.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004]

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[Fig. 1] Fig. 1 shows a waveform at point A in a structural view of a circuit shown in Fig. 2.

[0005]

[Fig. 2] Fig. 2 shows a circuit structure of a device, according to the present invention, for removing lead sulfate ($PbSO_4$) deposited on electrodes of a lead-acid battery.

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0006]

In the past, devices have been made which are designed to temporarily recover the performance of a lead-acid battery by giving electric shocks between lead sulfate ($PbSO_4$) deposits, which have been largely built up on surfaces of electrodes of a lead-acid battery, and the surfaces of the electrodes, thereby removing the lead sulfate ($PbSO_4$) deposits from the electrodes and dropping the removed lead sulfate ($PbSO_4$) deposits under the electrodes. In these devices, however, the recovery of the performance of the lead-acid battery is only temporary. The reason is as follows: A prompt recovery of the relative density of an electrolyte solution cannot be achieved by simply dropping the lead sulfate ($PbSO_4$) deposits under the electrodes after removing the deposits from the electrodes. To achieve a prompt recovery of the relative density of the electrolyte solution, dilute sulfuric acid must be added. However, after the addition, the lead sulfate ($PbSO_4$) deposits left under the electrodes are gradually dissolved

back into the solution, which causes an abnormal increase in the relative density of the solution and subsequent damage to the surfaces of the electrodes. As a result, the entire electrodes are destroyed, shortening the lifetime of

5   the lead-acid battery itself.

MEANS TO SOLVE THE PROBLEMS

[0007]

Instead of a method of simply dropping lead sulfate ($PbSO_4$) deposits largely built up on surfaces of electrodes

10   of a lead-acid battery under the electrodes, we have invented a method for recovering the performance of a lead-acid battery, which is conducted in the following manner. First, by continuously applying a current generated by a spike-shaped voltage pulse of duration (Tb) of 1 μs or less

15   pointing in a negative direction from a positive voltage E (v) at a frequency of 1 kHz to 100 kHz, lead sulfate ($PbSO_4$) deposits are continuously destroyed without damage to the electrodes, due to a skin effect and a skin depth determined by the skin effect, gradually from portions

20   closer to projecting crystal surfaces of the lead sulfate ($PbSO_4$) deposits. The destroyed lead sulfate ($PbSO_4$) deposits are returned, in the form of ultrafine lead sulfate particles, to dilute sulfuric acid. Thereafter, by charging the battery, the destroyed lead sulfate ($PbSO_4$)

25   deposits are dissociated into Pb^+ and SO_4^- in the dilute sulfuric acid solution, which subsequently return to the respective electrodes. In this method, because a current is not directly applied to the electrodes of the lead-acid

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battery, there is no damage to the electrodes. Further, the relative density of the lead-acid battery is recovered in proportion to an amount of time of the current application, to thereby recover the performance of the

5   lead-acid battery.

EFFECTS OF THE INVENTION

[0008]

Using a device for removing lead sulfate ($PbSO_4$) deposited on electrodes of a lead-acid battery, a current

10 generated by a spike-shaped voltage pulse of a short duration (Tb) of 1 μs or less pointing in a negative direction from a positive voltage E (v) was applied at a frequency of 1 kHz to 100 kHz between positive and negative electrodes of a lead-acid battery. As a result, crystal

15 surface portions of largely built-up lead sulfate ($PbSO_4$) were destroyed due to intensive concentrations of charge on projecting portions of crystal surfaces, a skin effect, and a skin depth determined by the skin effect, and were gradually converted into sulfuric acid (H_2SO_4), lead (Pb),

20 lead dioxide (PbO_2), and water (H_2O), to thereby recondition the lead-acid battery to its as-manufactured condition.

BEST MODE FOR CARRYING OUT THE INVENTION

[0009]

In order to convert lead sulfate ($PbSO_4$) largely

25 built up on electrodes into sulfuric acid (H_2SO_4), lead (Pb), lead dioxide (PbO_2) and water (H_2O), we have invented a method of applying, through the electrodes, a current generated by a spike-shaped voltage pulse of duration (Tb)

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of 1 μs or less pointing in a negative direction from a
positive voltage E (v) at a frequency of 1 kHz to 100 kHz.
Due to a skin effect and a penetration depth (which is
estimated to be 0.01 mm or less) which is determined by a
skin depth associated with the skin effect, the current
generated by the negative-pointing, spike-shaped voltage
pulse of a short duration (Tb) of 1 μs or less acts to
intensively destroy only very thin surface portions of lead
sulfate crystals. Further, the destruction of the lead
sulfate ($PbSO_4$) deposits built up between the positive and
the negative electrodes of the lead-acid battery occurs
gradually, starting from a point where the crystals are
spaced apart from each other by the smallest distance
between the electrodes. Therefore, without damage to the
electrodes, lead sulfate ($PbSO_4$) crystals float, in the
form of ultrafine lead sulfate ($PbSO_4$) particles, in dilute
sulfuric acid. Thereafter, by charging the lead-acid
battery, the lead sulfate ($PbSO_4$) crystals are dissociated
into Pb^+ and SO_4^- in the dilute sulfuric acid solution,
which subsequently return to the respective electrodes, to
thereby recover the initial relative density and
recondition the lead-acid battery. The recovery time to
restore the performance of the lead-acid battery varies,
depending on a change in frequency of the applied current,
which ranges from 1 kHz to 100 kHz.

Embodiment

[0010]

A current generated by a negative-pointing, spike-

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shaped voltage pulse of duration (Tb) of 1 μs or less is
generated by a reverse voltage pulse generator, and is
applied at a frequency of 1 kHz to 100 kHz to electrodes of
a lead-acid battery. As a result, due to a skin effect and

5   a skin depth determined by a pulse duration associated with
the skin effect, lead sulfate ($PbSO_4$) deposits are
destroyed, gradually from substantially projecting portions
of lead sulfate ($PbSO_4$) crystal surfaces. Thereafter, by
charging the battery, the destroyed lead sulfate ($PbSO_4$)

10   crystals are converted into sulfuric acid (H_2SO_4), lead (Pb),
lead dioxide (PbO_2) and water (H_2O). By repeating a process
of applying a current generated by a spike-shaped voltage
pulse of duration (Tb) of 1 μs or less pointing in a
negative direction from a positive voltage E (v) and

15   charging the battery, lead sulfate ($PbSO_4$) crystals
deposited on the electrode surfaces of the lead-acid
battery are destroyed, to thereby restore a porous
structure of the electrodes and the performance of the
lead-acid battery.

20   [0011]

        The duration of the spike is set at 1 μs, but can be
set at any value less than 1 μs. However, from an
engineering point of view, it is difficult to generate
spike-shaped voltage pulses of a short duration (Tb) of a

25   few nanoseconds at a reasonable cost. Therefore, the
duration of the spike is set at 1 μs, which does not
practically pose a problem.

     [0012]

The magnitude of a reverse voltage is set at a value approximately four times greater than the magnitude of power source voltage E (v), but can be set at any value greater than that. The reverse voltage should be

5   determined according to the size of electrodes of a lead-acid battery.

[0013]

The frequency of repetitive applications of the reverse voltage is set at 1 kHz to 100 kHz. However, an

10   optimal frequency should be chosen according to the size of electrodes of a lead-acid battery, the conditions of lead sulfate ($PbSO_4$), and the length of recovery time.